

New constraints on seawater chemistry from Mesoarchean carbonates, Canada

LIYUAN LIANG^{1*}, MUNIRA AFROZ^{2,3}, PHILIP FRALICK², STEFAN V. LALONDE³, BRITTANY RAMSAY², ROBERT RIDING¹

¹Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, Tennessee, USA

²Geology Department, Lakehead University, Thunder Bay, Ontario, Canada

³CNRS-UMR6538 Géosciences Océan, European Institute for Marine Studies, Plouzané, France

*Correspondence: lliang1@utk.edu

New field observations show seaward margins of 2.8–2.95 Ga carbonate platforms in Red Lake Greenstone Belt (north-western Superior province, Canada) contain iron oxide and calcium carbonate precipitates interlayered in proportions of ~1:5–1:6 thickness. Precipitation is inferred to have occurred as offshore anoxic seawater mixed with oxygenated water at the ‘Oxygen Oasis’ platform margin [1]. Iron formation deposited in the offshore basin is mainly chert, magnetite, pyritiferous carbonaceous slate and rare siderite [2]. Although likely altered during early diagenesis, these sediments suggest that offshore seawater chemistry favoured Fe-carbonates (e.g., siderite), and inhibited Ca-carbonate precipitation. Oxidation at the platform margin removed Fe²⁺ by precipitating iron (oxy)hydroxide. This in turn favoured first aragonite and then calcite precipitation to create the carbonate platforms.

Previous work suggests that Archean chemical sediments may be used to infer seawater composition and p_{CO2} if these minerals precipitated in the water column [3, 4, 5]. We used a thermodynamic speciation model to quantitatively evaluate the amounts of precipitates that would form at chemical equilibrium due to Fe²⁺ removal, by varying temperature, p_{CO2}, pH, Ca²⁺ and Fe²⁺ to set initial and equilibrium conditions. We then used the new field observations of the relative abundances of interlayered CaCO₃ and iron oxide to constrain Fe and Ca concentrations in solution. This model in turn provides new estimates of pH and p_{CO2} values during the Mesoarchean, a critical time when large carbonate platforms began depositing for the first time in Earth history.

[1] Riding, Fralick & Liang (2014), *Precambrian Research* 251, 232–237; [2] Fralick & Riding (2015), *Earth-Science Reviews* 15, 132–175. [3] Holland (1984). *The chemical evolution of the atmosphere and oceans*. Princeton University Press. 582 pp. [4] Rosing, Bird, Sleep & Bjerrum (2011). *Nature* 474, E4–E5. [5] Johnson, Ludois, Beard, Beukes & Heimann (2013) *Geology* 41, 1147–1150.